The Application of Visual Analytics to Financial Stability Monitoring

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Financial Stability Monitoring

Macro-prudential Supervisors

• Identify new sources of financial instability
• Maintain situational awareness of developing stresses
• Make decisions and rules
• Promote transparency of information to market participants
Macro-prudential supervisors’ challenges

1. Financial system – complex, enormous, highly diverse, and constantly changing

2. The system generates voluminous, dynamic and heterogeneous data/information, at ever-increasing rate (but, of varying reliability, completeness and uncertainty)

3. Large, diverse and growing financial and economic models to comprehend threats to financial stability

4. Transparency and accountability in certain regulatory activities can complicate / restrict the choices of tools and approaches
Challenges in monitoring financial (in)stability
Challenge 1: The Multifaceted Nature of Systemic Risks

- There is no universally accepted definition of systemic risks
- No analytical solution will address all the requirements
- Human judgment will remain an integral part of the analytical process
- Computational tools such as visualizations can support the human effort
Challenge 2: Acquiring The Right Type and Adequate Quality Of Data

- Need to know the quality, accuracy, reliability and (lack) of coverage of data (e.g. G-20 initiated a process to identify data gaps)
Challenge 3: Organizational Issues

Macroprudential supervisors:

• Convert data on institutional and financial market conditions into analyses and formal decisions

1. General monitoring – track potentially stressful conditions in the financial sector
   • Situational awareness requires diverse and flexible tools to facilitate the analysts’ understanding of evolving conditions

2. Formal supervision – regulatory enforcement actions
   • Formal decisions with tangible consequences require techniques and tools which are pre-defined, but streamlined for clarity and ex-post accountability
Challenge 4: Identifying and Visually Representing Underlying Processes

- Well designed *visualizations* are an effective communicator
- Vital to understand the relationships among multiple entities and concepts
Challenge 4: Identifying and Visually Representing Underlying Processes

• Identify over-arching function relating core concepts and their relationships across different processes in a system
• Choose appropriate renderings to enable rapid assessment of overall system state, with capability to rapidly interrogate state of sub-systems and components
• One technique from Cognitive Systems Engineering is the Abstraction-Decomposition Hierarchy\textsuperscript{1\&2}
• Unified Model of Systemic Risk\textsuperscript{3} provides an abstract description of financial system components and sub-systems, projecting contracts, market behaviors, income, revenues and liquidity into abstract cash-flow patterns and relationships for a composable representation of financial risk.
• Visually representing financial stability:
  — To unambiguously show relationships integrating crucial financial stability factors, such as credit exposure, leverage, or liquidity

Base Architecture for Mapping Risk Factors to Risk Measures

Potential Solutions

- Visualization
- Visual Analytics
Visualization

• A Picture is worth a thousand words
• The process of analyzing and transforming non-spatial data into an effective visual form to amplify cognition
• Exploiting the humans’ visual perception and cognition
• A highly efficient way for the human to directly perceive data and discover knowledge and insight from it
• Users know or have decided what they want to “look at”
## Classification of Visualization Techniques

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<thead>
<tr>
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<th>NON-INTERACTIVE</th>
<th>INTERACTIVE</th>
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<tbody>
<tr>
<td><strong>STATIC</strong></td>
<td>No user input after initial rendering, and image does not change, “Fixed”</td>
<td>Ongoing user input, but rendering does not change between input events</td>
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<td>Example: Newspaper infographic</td>
<td>Example: Dental x-rays</td>
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<tr>
<td><strong>DYNAMIC</strong></td>
<td>No user input after initial rendering, but image may change</td>
<td>Ongoing user input, and rendering may change between input events</td>
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<tr>
<td></td>
<td>Example: Animated GIF</td>
<td>Example: Video game</td>
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Static Visualization

• Pre-composed views of data

• Multiple static views are used to present different perspectives on the same information
Example 1: The Depiction Of Economic Value For Individual Firms And Sectors

• Concentrated risk exposure is an unsustainably large contingent obligation (or aggregation of them)
• If triggered would lead to the failure of a financial firm or system
• Federal Reserve recently introduced Y-14 to collect instituted contract level data
• Individual firm – Basel Committee on Banking Supervision (BCBS) has codified standards for reporting bank capital, risk-weighted assets and acceptable leverage
• Key abstractions for systemic risk analysis - bank failures and bond defaults
Example 1a: The Depiction Of Economic Value For Individual Firms

- This, for example, is a visualization of the People’s Bank of China’s balance sheet for managing currency, it shows the accumulation of risk over time.

Risk Accumulation at the Bank Level

Example 1b: The Depiction Of Economic Value For Sectors

Risk Accumulation at the Bank Level

• Standardisation of accounting data enables cross-firm aggregations
• Normalised ratios are aggregated nationally and compared for a broad cross-section of countries
• The closer a banking system is to the centre, the more adjustment it still needs to undertake

Ranking of large banking system in risk concentration
(1) Loss-absorption capacity, (2) asset quality, (3) profitability and (4) reliance of wholesale funding

Global Financial Stability Report, Old Risks, New Challenges, IMF, April 2013,
Example 1c: US Bank Suspensions

1921 – 1929

Agriculture-related bank failures

1931

Urban and Eastern
Example 2: Network Analysis – Systemic Interconnectedness

- Fedwire Interbank Payment Network
  - 6,600 nodes and 70,000 links

- Core Network payment - 75% transferred value
  - 66 nodes and 181 links

Potential loss of information and/or context, e.g. anomaly

Network Abstraction – Aggregate Nodes/Links with Similar Properties

Provide visual clarity
Maintain underlying network characteristics

Example 3: Revealing Changes Over Time

US Treasury yield curve 1990 – 2010
Short term rate driven by fluctuations in investment demand - decline in inflation rates

Static Visualization

• **Advantage**
  – When alternative views are not necessary nor desired, for example when publishing in a static medium.

• **Disadvantages**
  – Limited number of data dimensions when all visual elements are presented on the same surface at the same time
  – Difficult to represent multi-dimensional data fairly, thus could result in some aspects of the data not being explored/exploited or even missed.

• **Users have to decide or know in advance what they want to “look at”**
Dynamic Financial Systemic Risk Analysis
Visual Analytics

• Users do not necessarily know in advance what to look at or the characteristics of the data
• There will always be new emergent risks that require new approaches to their detection and identification
• Must incorporate diverse perspectives
• Continuous re-evaluation of the evolving structure of the financial system
• Adapt systemic risk metrics to dynamic and unpredictable changes
• Perform:
  – Sense-making
  – Decision-making
  – Rulemaking
  – Transparency
What is Visual Analytics?

- *Visual Analytics* is the science of analytical reasoning supported by interactive visual interfaces

(Thomas and Cook, 2005)
What is Visual Analytics?

Data analysis

Visualization + Representation

Interactive dynamics

NLP, text analysis, knowledge management, entity extraction, semantic analysis methods eg Latent Semantic Analysis

Human sense-making

Analysis, results, and representation that are in a tightly coupled perception-action loop

Assembly of evidence

Visual Analytics

• Users explore the data interactively to gain an understanding of the data
  – Detect the expected
  – Discover the unexpected
  For situational awareness, decision- and rule-making
• It is not fixated on any model or dependent on any specific data
• Both the questions and the nature of the answers are unknown
Displays the relationships among accounts, time, and keywords within the transactions - overview of the data. User can interactively compare, aggregate, and organize groups of transactions and drill down into and comparing individual records.
RiskVA – Consumer credit risk analysis

Interactive analysis of the 30-day delinquency rate in market across a range of consumers

Dashboard - 519 Failed Banks 2000 – 2014

State - total assets

Temporal pattern

Treemap

Overview – bank headquarter locations, acquirors, assets, timing of bank failures
Interactive Exploration – Texas Bank Failures

12 failed banks, their total assets and when were they acquired by the 10 institutions
Visualization and Visual Analytics of Failed Banks

Dashboard - 519 Failed Banks 2000 – 2014

Static Visualization

Exploratory Visual Analytics
Conclusions

- Visual analytics and visualization are promising approaches for monitoring financial (in)stability:
  - detecting,
  - identifying,
  - monitoring and
  - managing
threats to global financial stability
Future Research 1

• Definition of core abstractions
  – Bridging the gap between financial domain abstractions and visualization

• Definition of canonical algorithms
  – Need for precise and semantically relevant (fast) algorithms that can be embedded in visual analytics

• Users
  – Interaction with and support from the users during the conception, development and evaluation of the visual analytics algorithms / tools / systems
Future Research 2

• Provision of standardised data
  – For development, implementation and evaluation of visual analytics tools
• Evaluation techniques
  – Need to be able to assess the performance and effectiveness of the visual analytics algorithms / tools / systems